Industry Foundation Classes - Release 2.0

Specifications Volume 4

IFC Software Implementation Certification Guide

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International Alliance for Interoperability
Enabling Interoperability in the AEC Industry

Industry Foundation Classes - Release 2.0

Specifications Volume 4

IFC Software Implementation Certification Guide

Enabling Interoperability in the AEC/FM Industry

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1. Introduction, Scope and Assumptions

1.1. Purpose of these documents

The purpose of this document suite is to provide a detailed specification of the Industry Foundation Classes (IFC) as defined by the Industry Alliance for Interoperability (IAI). The intended audience is the IAI membership, industry domain experts, and software developers interested in implementing IFC.

1.2. IFC Release Document Suite

IFC will be documented for two readers. The AEC professional and the software profession serving the AEC industry. Documents in this release include:

An Introduction to IAI and IFC

The "*An Introduction to IAI and IFC,"* as the name implies, provides AEC/FM industry professionals with an introduction to the organization, including its mission and organization. It also introduces the shared project model concept, end user benefits in using IFC compliant applications and summarizes the AEC Industry processes that are supported by this release of IFC. Finally, it provides a preview of what will be added in future releases.

IFC Specification Development Guide

The *"IFC Specification Development Guide"* defines the process used by the IAI in developing IFC. It also provides various references supporting parts of this process such as development of process diagrams, development of detailed requirement definitions and reading/creating EXPRESS (data model) definitions and EXPRESS-G diagrams.
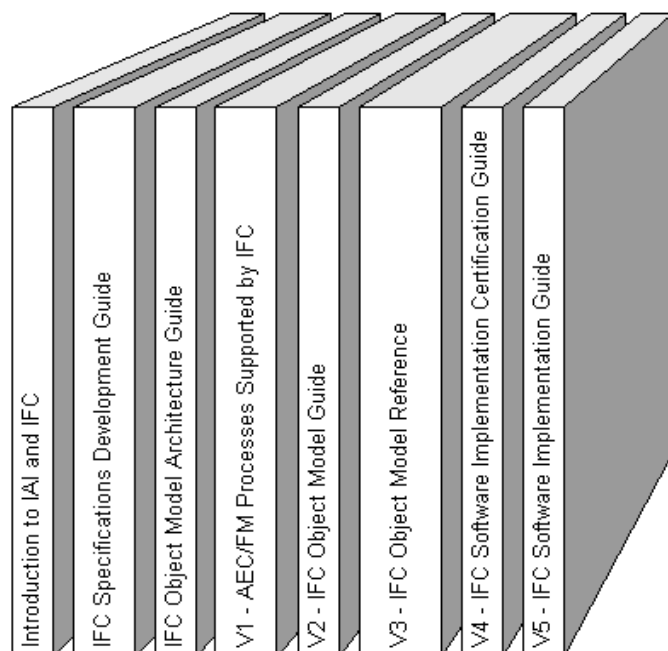
IFC Object Model Architecture Guide

The *"IFC Object Model Architecture G*uide*"* defines the architecture used in the design of the IFC object model. This architecture is modular and layered which allows independent development and evolution of sub-schemata. This document is written for software developers who will develop applications supporting IFC.

Volume 1: AEC/FM Processes Supported by IFC

THIS DOCUMENT -- The "*AEC/FM Processes Supported by IFC"* volume documents the AEC/FM industry processes that the IFC Project Model in this release is designed to support. Therefore, this document effectively defines the scope of AEC project information included in this Release. Volumes 2 and 3 structure this information as software objects in AEC software. Note that this IFC release is limited to the information content of the foundation classes defined. Behavior for these objects, and thus the implementation of software that will support these AEC industry processes, will be defined by the implementing software vendors.

Volume 2: IFC Object Model Guide

The "*IFC Object Model Guide"* defines model design and use concepts for IFC object model. These key concepts include: an overview of model architecture, capturing design intent, sharing semantic relationships, model extension by application developers. It also describes some implementation strategies such as file based model exchange, Client-Server architectures and runtime interoperability supported through standard software interfaces of the IFC model. This includes an overview and example of the physical file format for file based model exchange.

Volume 3: IFC Object Model Reference

The "*IFC Object Model Reference"* provides detailed definitions for each of the classes and data types defined in the IFC object model. This includes all of the information required by the AEC processes defined in volume 1, structured in an information model detailing object class data, relationships, standard interfaces, type definitions and geometry schema use for shape representation. Additionally, it provides a data model view defined in EXPRESS and a standard interfaces view defined in IDL. Each of these code sets will be used by application developers as input into Computer Aided Software Engineering (CASE) tools to semi-automate development of applications intended to support IFC. Finally, a on-line version of this information is provided in an HTML document set that is cross linked for easy access to information related to or supporting a particular class or data type.

Volume 4: IFC Software Implementation Certification Guide

The "*IFC Software implementation Certification Guide"* provides detailed information about conformance certifications issues and the methodology that will be used by the IAI to certify applications for multiple levels of IFC conformance. This includes an overview of the concepts for conformance assessment and certification, definition of various "Exchange Set" subsets of the IFC model for which certification can be assessed and an overview of the testing suites that will be used for certification testing.

Volume 5: IFC Software Implementation Guide

The "*IFC Software implementation Guide"* provides detailed information addressing the issues of implementing the IFC object model in software products. In this release, it's content is limited to the topics of implementing property sets (previously called "Pset Guide") and the differences from the previous release (previously called "Migration Guide"). Over the next couple of IFC releases, many more topics will be addressed.

1.3. Scope

1.3.1. Scope for IFC Release 2.0

Enabling interoperability between applications by different software vendors is the ultimate goal of the IAI. This is a very ambitious goal and will be achieved through a series of incremental steps.

In general, the IAI is focused on providing three things in IFC:

1. Standard definitions for the attributes associated with entities comprising an AEC/FM project model (objects)

2. Structure and relationships between these entities from the point of view of various AEC/FM professionals

3. Standard formats/protocols for two methods of sharing this information:
   - *exchange via a standard file format*
   - *exchange via standard software interfaces*

It is important to note that the software interface specifications in this release will not include any application-specific behavior. Instead, these interfaces will be limited to get and set methods for the attribute and relationship information defined in the data model.

Release 1.5 of IFC provided the infrastructure that supports this release, plus reasonable models for architecture, some HVAC, estimating, scheduling and Facilities Management. This release will build on these foundations and extend the model in several areas.

The scope for this release of the IFC Specifications is limited to:

1. Six AEC/FM domains - Architecture, HVAC engineering, codes and standards, cost estimating, facilities management and simulation

2. Only a specific subset of the processes in these domains (defined in Volume 1 of these specifications).

These domains and processes are:

Architectural Design
- *Building 'shell' design*
- *Building 'core' design*
  - Stair design
  - Public toilet design
- *Roof design*
- *Fire Compartmentation*

HVAC Engineering
- *HVAC Duct System Design*
- *HVAC Piping System Design*
- *Pathway Design and Coordination*
- *Building Heating and Cooling Load Calculation*

Codes and Standards
- *Commercial and Residential Energy Code Compliance Checking*

Cost Estimating
- *Cost Estimating*
  - Identify Objects
  - Identify Tasks Needed to Install Objects
  - Identify Resources Needed to Perform Tasks
  - Quantify
  - Costing and Cost Summarization

Facilities Management
- *Property Management*
  - Enabling the use of IFC objects in property management
  - Grouping IFC objects
  - Linking the maintenance objects to the IFC objects
- *Occupancy Planning*
- *Design of Workstations*
- *Floor Layout of Workstations for an Open Office*

Simulation
- *Photo Accurate Visualization*

All AEC domains
- *Document references (from model to document only)*

1.3.2. Scope of this document

This document includes the following information:

1. Introduction, Scope and Assumptions

   Provides the reader with an introduction to the set of five volumes comprising this release of the IFC Specifications. This section outlines the information included in this document versus related documents. It will also define the scope for this release and assumptions about knowledge of the reader.

2. Concepts

   This section describes the general concepts affecting software implementations seeking IAI certification. It describes how interoperability via file-based exchange is to be achieved, as well as introduces the concepts of Exchange Views, Formal Test Cases, and the Test Kits for software implementations seeking IAI certification.

3. Conformance Certification Process

   This section describes the steps a software developer must take to obtain permission to use the IAI logo for identification of their products as being IAI certified based on the defined Exchange Views for the product market sector.

4. Exchange Views

   This section details the concepts of Exchange Views that a software implementation must support for minimum IAI certification. The Exchange Views are driven by software implementations to ensure that vertical market segments of the AEC/FM industry can adequately exchange data.

5. Formal Test Cases

   This section includes information about the Formal Test Cases are generated. It also includes a sample Formal Test Case to illustrate the steps implementers will use to demonstrate compliance with this release of the IFC specifications.

6. Appendix A: Implementation Certification Application for IFC 2.0

   This section includes an application that must be filed with the IAI to begin the process for obtaining IFC 2.0 Conformance Certification.

1.4. Assumptions and Abbreviations

This document assumes the reader is reasonably familiar with the following:

- AEC/FM market and project terminology
- Software industry terminology
- Concepts and terminology associated with object oriented software

The following abbreviations are used throughout the IFC Specifications:

- AEC/FM   Architectural, Engineering, Construction and Facilities Management
- IAI   Industry Alliance for Interoperability
- AP   Application Protocol
- Arch   Architecture
- CM   Construction Management
- CORBA   Common Object Request Broker Architecture
- COM   Microsoft's Component Object Model
- DCE   Distributed Computing Environment
- DCOM   Microsoft's Distributed Component Object Model
- DSOM   IBM's Distributed System Object Model
- FM   Facilities Management
- FTP   File Transfer Protocol
- GUID   Globally Unique Identifier
- HVAC   Heating, Ventilating and Air Conditioning
- HTTP   Hypertext Transport Protocol
- IAI   International Alliance for Interoperability
- IDL   Interface Definition Language
- IFC   Industry Foundation Classes
- ISO   International Standards Organization
- FM   Facilities Management
- MIDL   Microsoft's Interface Definition Language
- ODL   Microsoft's Object Description Language
- OMG   Object Management Group
- ORB   Object Request Broker
- OSF   Open Software Foundation
- RPC   Remote Procedure Call
- SOM   IBM's System Object Model
- STEP   Standard for the Exchange of Product Model Data
- TCP/IP   Transmission Control Protocol/Internet Protocol
- TQM   Total Quality Management
- URL   Universal Resource Location

1.5. International Alliance for Interoperability (IAI)

The IAI is a 'not for profit' industry alliance of companies.   Its membership is comprised of visionary companies representing all sectors of the AEC industry worldwide.

The IAI was first formed in September of 1995, by 12 industry leading companies who, during the previous year had worked together to develop proof of concept prototypes demonstrating the viability of interoperability between AEC software applications. This demonstration was shown publicly at the AEC Systems '95 conference in Atlanta, Georgia. This is the third release of IFC since that time. There are currently 50 organizations implementing software to support IFC, a number that is growing quite rapidly now.

As of this printing, the IAI includes 9 international chapters with hundreds of member companies in the following regions:

- Australasian countries
- French speaking region of Europe
- German speaking region of Europe
- Japan
- Korea
- Nordic countries of Europe
- North America
- Singapore
- United Kingdom

The IAI stated Vision, Mission and Values can be summarized as:

VISION

Enabling Interoperability in the A/E/C/FM Industry

MISSION

To define, promote and publish specifications for the Industry Foundation Classes (IFC) as a basis for information sharing through the project life cycle, globally, across disciplines and technical applications.

VALUES

- Not for profit industry organization
- Action oriented (Alliance v. Association)
- Consensus based decision making
- Incremental delivery (rather than prolonged study)
- Global solution
- Industry to define IFC
- IFC to be "open" (for implementation/use by all software vendors)
- Design for IFC to be extensible
- IFC will evolve over time
- Membership open to any company working in construction industry

2. Concepts

2.1. Introduction

2.1.1. Purpose

The purpose of this section is to define the general concepts which are to be utilized by the International Alliance for Interoperability (IAI) for software implementations which desire to be certified as conformant with this release of the Industry Foundation Class (IFC) Specifications.

2.1.2. Overview

True interoperability requires more than the translation between different formats of data. The key to interoperability is the capability, based on exchange or sharing of data, of *users* to communicate and work with each other independent of any particular application software that they are using.
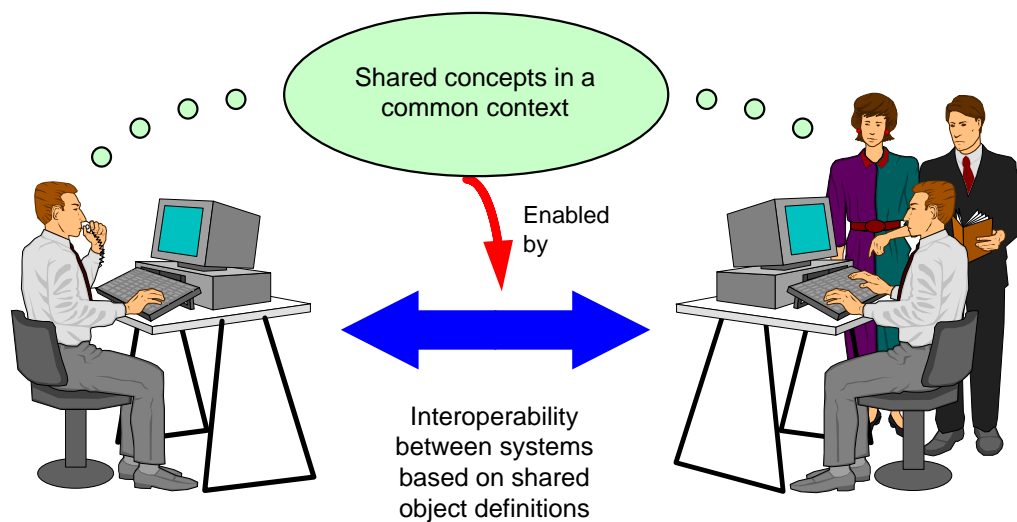
Figure 1: Interoperability

The role of IFC is to enable interoperability, based on well defined, unambiguous definitions. In practical terms, this means that users of different IFC compliant software applications are able to engage in meaningful communication.

For file based data exchange, consideration of interoperability typically focuses on the details of computer-to-computer aspects of communication, as shown in Figure 2. Here, applications communicate based on the exchange of common data via a physical file. By adopting an approach similar to conformance testing based on CAD/CAM exchange, graphics, and OSI standards, interoperability can be predicated on software applications that completely and accurately support the requirements for translation between their internal data structures and those prescribed by the IFC Specifications.

Figure 2: Interoperable applications using file-based data exchange

For object based data exchange, the focus of interoperability shifts to the ability of different software components produced b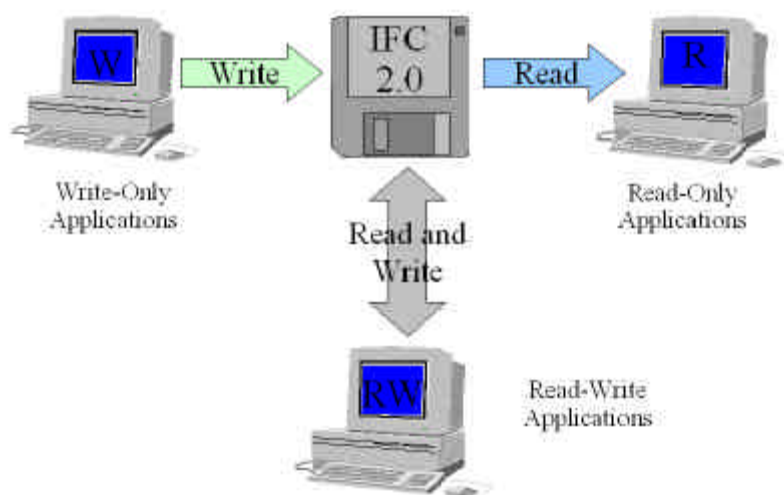y various software vendors to be able to interrogate and utilize the functionality provided by these multi-vendor components. The IFC Specifications include software interface definitions which are intended to facilitate this environment. However, components that participate in a collaborative environment must be able to maintain the overall integrity of the project data. As a consequence, such an environment must also be capable of file-based exchange for model archiving purposes.

2.1.3. Scope

The scope of this guide is the assessment of conformance to the IFC specifications developed by the IAI. The scope of conformance assessment considered here is the exchange between software applications of data that conforms to the IFC specifications.

2.1.3.1. Static File Exchange and Runtime Software Interfaces

The IFC Specifications provide two mechanisms to achieve interoperability: static file based exchange and runtime software interfaces. For this release of IFC, obtaining software implementation certification will focus solely on file based exchange using the syntax and rules of *ISO 10303-21:1994, Industrial Automation Systems - Exchange of Product Model Data - Part 21: Implementation Methods; Clear Text Encoding of the Data Structure*.

The IAI intends to introduce a formalized mechanism for obtaining software implementation certification for applications relying solely on runtime software interfaces in future editions of the IFC Specifications. Consequently, conformance certification for applications based solely on object based data exchange is out of scope for this release of the IFC Specifications.

Assessment of the use of the IFC specifications within an application is out of scope of this guide. However, it should be noted that the basic principles of the IFC Conformance Certification procedure must be equally applicable to file exchange, shared databases or the use of runtime software interfaces.

2.1.3.2. Complete versus Partial Model Exchange

Conformance Certification for this release of the IFC Specifications requires that a complete model file supporting a predefined Exchange View must be exchanged. Exchange Views typically define subsets of the IFC model aligned towards a particular AEC/FM domain or activity, and consequently only partial model exchange is required for establishing Conformance Certification with this release of IFC.

It is the responsibility of the software implementation to provide adequate facilities for merging these partial models with a complete model definition when required. Merging partial models with complete models is out of scope for this guide.

2.1.3.3. Read Only, Write Only and Read-Write Applications

For file based data exchange, the focus of conformance assessment is on the *mechanism* of exchange and on the assessment of the behavior of the application software. The following three types of applications are eligible for seeking IFC Conformance Certification:

Read Only Applications: Applications that have an input or "read" facility which shall be able to read an IFC file containing syntactically correct instances of IFC classes and property sets defined within the Exchange View.

Write-Only Applications: Applications that have an output or "write" facility which shall be able to create physical files that include syntactically correct instances of IFC classes and property sets defined within the Exchange View.

Read-Write Applications: Applications that have an input or "read" facility and an output or "write" facility capable of reading and writing a physical file that includes syntactically correct instances of IFC classes and property sets within the Exchange View.

There is no differentiation between these three types of applications for obtaining IFC Conformance Certification. All are within the scope covered by this guide.

2.1.3.4. Certification Process

The IAI will make available Formal Test Cases that are focused on exercising leaf-node or instantiable classes within the IFC model. These atomic tests consist of one or more procedures applicable to the specified class as constrained by the Exchange View. It also contains an instantiated IFC file for the software developer to use within the context of the test. The Formal Test Cases are based on the Exchange Views that have been collectively defined by the IAI member companies that are software developers. Obtaining and utilizing these Formal Test Cases are detailed later in this document.

The vendor seeking Certification must also participate in an Interoperability Workshop. The purpose of the workshop is to demonstrate to an appointed representative of the IAI that interoperability is achieved under live data exchange conditions with other IFC applications. These workshops are open to the public and potential end-users will be encouraged to attend and witness the tests.

Applications, which successfully demonstrate IFC compliance, will be authorized to carry the IAI Certification logo qualifying the release number and Exchange View for which they have been certified. This mark can be used on the software application's packaging or labeling and indicates such conformance and provides end users of the software with confidence in the ability of the software to perform with a described and specified quality. All results from the Conformance Certification process will be made publicly available on the international Web and/or FTP sites operated by the IAI.

Misuse of an authorized marking will be considered a serious breach of trust by the IAI. Chapters of the IAI reserve the right to take such action individually or in concert as may be considered appropriate to the breach. Tests and the claim of conformance to the IAI specifications are subject to audit by the IAI or by a competent independent agent who may be appointed by the IAI.

The costs of testing and assuring conformance with the IFC specifications are borne by the software developers seeking certification.

2.1.4. Terms, Abbreviations and Definitions

The following terms, abbreviations and definitions are provided here which may assist the reader:

Conformance Test Kit: The combination of documentation (electronic or hard copy), test cases and any other item required to perform conformance testing.

Exchange View: All or part of the current IFC model which is used to identify the requirements necessary for achieving Certification within a predefined scope.

Formal Test Case (FTC): An instantiation of a Sample Test Case used to formally assess the conformance of an implementation. The values within the FTC may be constrained to reflect the capability of the implementation being tested.

Implementer: An 'implementer' is defined as an organization which develops or markets a software product or offers the use of such a software product based on the IFC specifications.

Master Input File: Fully populated IFC file for use in round-trip testing in the Interoperability Workshop.

Reference Input File: IFC file for input within the Formal Test Cases developed on a per instantiated class.

Reference Output File: IFC file for comparison purposes within the Formal Test Cases developed on a per instantiated class.

Sample Test Case (STC): A specification that provides the authoritative basis from which Formal Test Cases are derived.

Target Output File: IFC file generated by a vendor seeking certification within the context of the Formal Test Cases developed on a per instantiated class.

3. Exchange Views

3.1. Exchange View Definitions

An Exchange View defines a specific subset of the IFC model that identifies on a per attribute basis, all requirements for applications that exchange data based on this view of the model. For example, CAD vendors are especially interested in the geometric representation of IFC objects. For these vendors, it is critical that all geometry definitions are included in their view of the IFC model. However, applications that deal specifically with cost estimating, for example, have different requirements for data exchange for these same objects. These cost estimating applications may not need detailed geometric representations, but instead need details that help to identify the subtleties of establishing a detailed cost estimate. For this very reason, different views of the same object definitions are required to support the various software applications that are used in the AEC/FM industry.

The Exchange View definitions are created in a collaborative effort with implementers interested in serving a particular aspect of the AEC/FM industry. Implementers individually decide which object views they need to support in their applications. This is then supplied to the IAI as part of the application for certification. Once certification begins, a certification database will be used to compile a record of all the Exchange Views supported by all certified applications. If an existing Exchange View does not match the needs of the application, then the IAI may consider expanding the Exchange View definitions so that additional or unforeseen applications may be accommodated.

It is expected that the various Exchange View definitions based on applications serving the AEC/FM industry may not contain mutually orthogonal views of the IFC model. As a consequence, end users wanting to exchange IFC data between two applications will use the IAI Web site to identify the areas of overlap between applications that have been certified for different Exchange Views. This will effectively communicate the IFC model subset that can be reliably exchanged between certified applications. IAI members and the AEC/FM industry must be educated to expect that certified applications support only parts of IFC and the parts that can be exchanged between applications will be different between any two applications.

3.2. Exchange View Example

The following tables show samples of what might be expected for applications that support various fictitious Exchange Views for IfcBuilding and IfcBeam class definitions. All Exchange Views include the mandatory attributes plus the set of optional attributes defined for that view as agreed by implementers. In these tables, if an attribute is marked as mandatory, then it is automatically marked in all views. Shading in some cells indicates that there is no choice (e.g. it was already required because it was mandatory or it is an "inverse" attribute and will not be written in the IFC file by any view).

Table 1: Sample IFC Exchange View Definitions for IfcBuilding

Class/Interface		Required to instantiate	Required to Support				
	Attribute	Mandatory attributed	Common View	CAD App View	Cost App View	Scheduling App View	Thermal Analysis App View
IfcBuilding							
I_Root							
	ProjectId	X	X	X	X	X	X
I_Object							
	OwnerHistory	X	X	X	X	X	X
	TypeDefinitions	X	X	X	X	X	X
	OccurrenceProperties	X	X	X	X	X	X
	ExtendedProperties	X	X	X	X	X	X
	PartOfGroups						
	Nests						

	IsNestedBy						
	Contains						
	IsContainedBy						
I_Product							
	LocalPlacement	X	X	X	X	X	X
	ProductShape			X	X		
	ProductCost				X		
	Classification			X			
	PrcessedInProcesses						
I_Building							
	GenericType	X	X	X	X	X	X
	calcTotalHeight			X			
	calcSiteCoverage			X			
	calcTotalVolume			X			
	ServicedBySystems						

Table 2 Sample IFC Exchange View Definitions for IfcBeam

Class/Interface		Required to instantiate	Required to Support				
	Attribute	Mandatory attributed	Common View	CAD App View	Cost App View	Scheduling App View	Thermal Analysis App View
IfcBeam							
I_Root							
	ProjectId	X	X	X	X	X	X
I_Object							
	OwnerHistory	X	X	X	X	X	X
	TypeDefinitions	X	X	X	X	X	X
	OccurrenceProperties	X	X	X	X	X	X
	ExtendedProperties	X	X	X	X	X	X
	PartOfGroups						
	Nests						
	IsNestedBy						
	Contains						
	IsContainedBy						
I_Product							
	LocalPlacement	X	X	X	X	X	X
	ProductShape			X	X		
	ProductCost				X		
	Classification			X			
	PrcessedInProcesses						
I_Element							
	ConnectedTo						
	ConnectedFrom						
	IsAssemblyThrough						
	PartOfAssembly						
I_BuildingElement							
	HasMaterial			X	X		X
	ProvidesBoundaries						
	HasOpenings						
	FillsVoids						
I_Beam							
	GenericType	X	X	X	X	X	X
	calcBeamSectionArea			X	X		
	calcBeamVolume			X	X		X

4. Conformance Certification Process

This section describes the necessary steps involved for completing the Conformance Certification process. Note that the IAI reserves the right to modify these procedures at any time.

4.1. Obtaining a Conformance Test Kit

When an implementer is satisfied that their software product is ready for formal testing and certification, an application form must be completed and submitted to the IAI. A copy of this application form is included in Appendix A.

Once the application has been filed and approved by the IAI, the implementer will be provided with a Conformance Test Kit containing the materials for use during the IFC Certification process. These materials include:

- Formal Test Cases for the classes and property sets defined by the Exchange View for which the implementer is seeking Certification
- Validation software for syntax checking of any generated IFC files
- A declaration of conformance statement
- The times and locations of upcoming Interoperability Workshops

4.2. Self-Tests Using Formal Test Cases

The Formal Test Cases are to be completed by the implementer prior to the Interoperability Workshop. Each test case details the criteria which shall be met in order to consider that a satisfactory result has been achieved. As each test is run and the test results are evaluated with the validation software, non-conformant issues must be addressed and the test repeated until suitable results are obtained. This is repeated for each applicable test.

When all the tests have been executed, the test report template is then completed showing the result of each of the tests. The vendor signs the declaration of conformance stating that the test report is an accurate and true reflection of the results of testing. The completed test report is then submitted together with output results from the validation software and submitted to the IAI. Completion and submission of these materials will be required prior to reserving space within the next Interoperability Workshop.

Any problems or issues surrounding the test kit must be notified immediately to the IAI. The issue will be distributed to the bodies responsible for generating the test kit.

Use of the Formal Test Cases is a prerequisite for any organization seeking Conformance Certification. The IAI shall elect, as required, an independent body to monitor and resolve any queries or problems found with the Test Kit or IFC Specifications. When problems are found, all users of the test kit must be informed immediately and tests withdrawn until corrected. Resolution of queries may involve all users of the Test Kit being asked for their input.

4.3. Interoperability Workshop

Participation in an Interoperability Workshop is by invitation from the IAI only and is required for achieving Conformance Certification. The purpose of the workshop is to demonstrate to the IAI that interoperability is achieved under live data exchange conditions with other IFC certified applications. These workshops are witnessed by a representative of the IAI and are open to the public. Potential end-users will be encouraged to attend and witness the tests.

4.4. Certification and Brand-marking

Upon successful completion of both the self-testing phase using the formal test cases provided by the IAI and the Interoperability Workshop, the IAI will certify the submitted application. Conformance enables use of the IFC mark on packaging and labeling.

All test reports and results for certified applications will be made publicly available on the IAI International Web/FTP site. These items of information may be further used by an authorized body of the IAI to carry out an audit of the testing procedures and results as it wishes.

> *The IAI is zealous in its protection of the correct usage and reputation of the IFC Conformance Mark. The IAI maintains the right to audit testing procedures and the correct usage of the IFC Should any of the submitted materials used for acquiring the Conformance Mark be found to be fraudulent, or should the application submitted to test be found unacceptable for use with other IFC certified products, the IAI reserves the right to rescind the use of the IFC Conformance Mark.*

The following Conformance Mark will be awarded to applications that are granted Certification by the IAI:

5. Formal Test Cases

This section includes information about the Formal Test Cases that software developers will use to demonstrate compliance with this release of the IFC specifications.

5.1. Sample Test Cases

Sample test cases are test data sets identified by domain experts as part of the process of identifying and characterizing usage scenarios, and during the development and validation of the IFC specifications. A sample test case is a potential source of Formal Test Case definitions if:

- it is related explicitly to one or more activities;
- it is related explicitly to one or more usage scenario;
- it focuses on a small group of related objects;
- it identifies all the data elements and options in terms of objects/attributes and assertions defined by the Exchange View;
- it includes textual and/or graphical descriptions of the data within the test case;

These criteria are used by the IAI identify a broad set of representative test cases. As well as forming the basis for the subsequent development of Formal Test Cases, sample test cases that meet these criteria are of potential use in development and validation of implementations as well.

5.2. From Sample Test Cases to Formal Test Cases (FTC's)

Sample test cases form a framework for the creation of meaningful groupings of Formal Test Cases, as illustrated below.
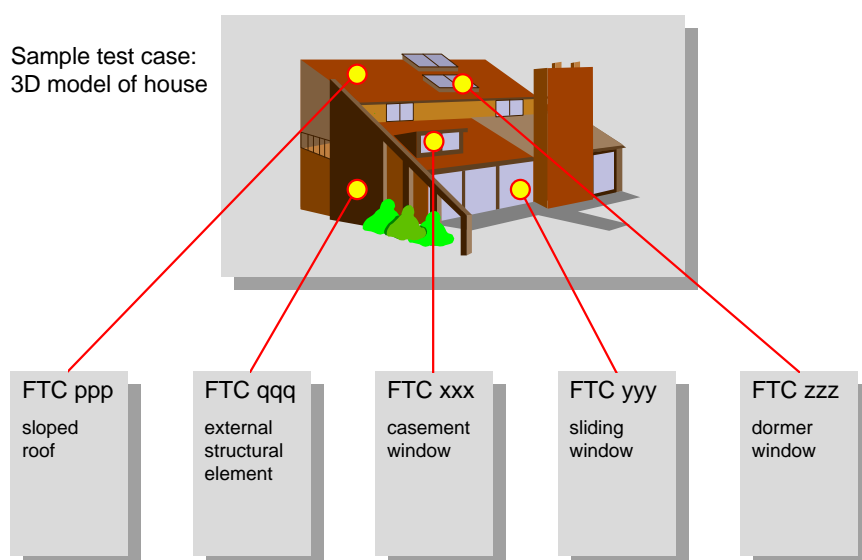

Figure 3: Formal Test Cases related to a Sample Test Case

Here, a sample test case has been identified for a specification whose requirements include classifications of building elements. In this example, a 3D model of a house has been chosen as the basis for a sample test case. Note that in this example the 3D model illustrated could either *be* the sample data (i.e., if the aspect(s) of the specification to be tested include 3D shape representation and presentation), or could be used to illustrate the aspect(s) to be tested (e.g., functional classification). Each sample test case and FTC will make this clear.

The benefits of this approach are as follows:

- The development and groupings of Formal Test Cases can be driven "top down" from the structure of the specification;
- Sample test cases, developed and validated in the specification development process, can be included as informative annexes in the Formal Test Case;
- Formal Test Cases can be presented and made available to the implementer and end-user as aspects of "meaningful" test data sets;
- Formal Test Cases themselves remain at the "atomic" level required by the formality of conformance testing.

The final, and possibly most significant benefit of this approach is that each individual Formal Test Case can be traced to the business processes that the specification supports by relating it, in turn, to Sample test case(s), Usage scenario(s), and activities or information flows. This traceability is completely in the domain of application experts.

5.3. Sample Formal Test Case

The following is a sample of a Formal Test Case designed to exercise a specific Exchange View for instances of IfcWall and IfcOpeningElement. This example is for informative use only.

5.3.1. Test Case Scope – Source Test File

The following classes are tested for read in compliance by this source test file:

- IfcProject
- IfcSite
- IfcBuilding
- IfcBuildingStorey
- IfcWall
- IfcOpeningElement
- IfcRelConnectsPathElements
- IfcRelVoidsElements
- IfcRelContains
- IfcLocalPlacement
- IfcAttDrivenExtrudedSolid
- IfcAttDrivenExtrudedSegment
- IfcRectangleProfileDef

5.3.1.1. Test Case Summary – Source Test File

The source test file comprises two walls. Both walls are single layer walls with rectangular cross sections and shall have equal heights. The walls shall be right-angled connected and shall have distinct connection priorities. An opening shall be inserted into one of the walls.

The building elements (walls and opening) are contained in a building storey, which is contained in a building, which in turn is contained in a site. All products shall be referenced by a project.

    containment: IfcWall, IfcOpeningElement → IfcBuildingStorey → IfcBuilding → IfcSite
    reference: IfcWall, IfcOpeningElement, IfcBuildingStorey, IfcBuilding, IfcSite → IfcProject

The opening shall be located relative to the wall. The walls shall be located relative to the building storey. The building storey shall be located relative to the building. The building shall be located relative to the site, which is located relative to the world coordinate system as established by the project.

    local placement IfcOpeningElement → IfcWall → IfcBuildingStorey → IfcBuilding → IfcSite →
        IfcProject

The geometric shape representation of the opening, walls, building storey, building, and site shall be in the context of this test case:
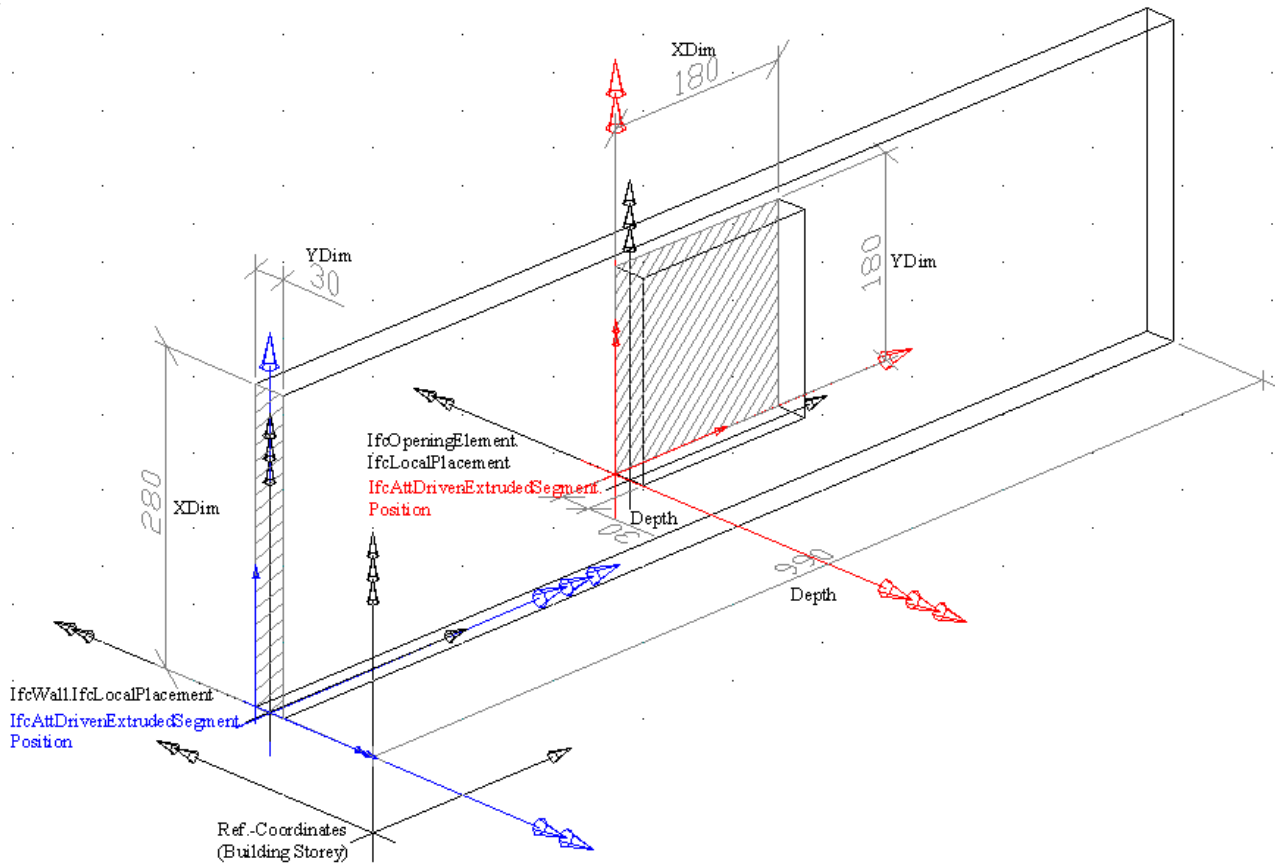
    IfcWall   standard geometric representation
    IfcOpeningElement   standard geometric representation
    IfcBuildingStorey   product shape not given

IfcBuilding   product shape not given
IfcSite   product shape not given

5.3.1.2. Shape for Source Test File

The following figure shows the shape for the walls and the opening. All dimensions are given in centimetres.

The following figure explains the use of standard shape representation, as required within the Geometry Use Section of IfcWall and IfcOpeningElement. It shows the coordinate systems for:

- local placement of IfcBuildingStorey, , IfcWall and IfcOpeningElement (black),
- the 3D-position of IfcAttDrivenExtrudedSegment (blue for the product shape of IfcWall and red for the product shape of IfcOpeningElement),
- the 2D-position of IfcAttDrivenProfileDef (blue for the product shape of IfcWall and red for the product shape of IfcOpeningElement).

Floor plan

Section

Isometric view
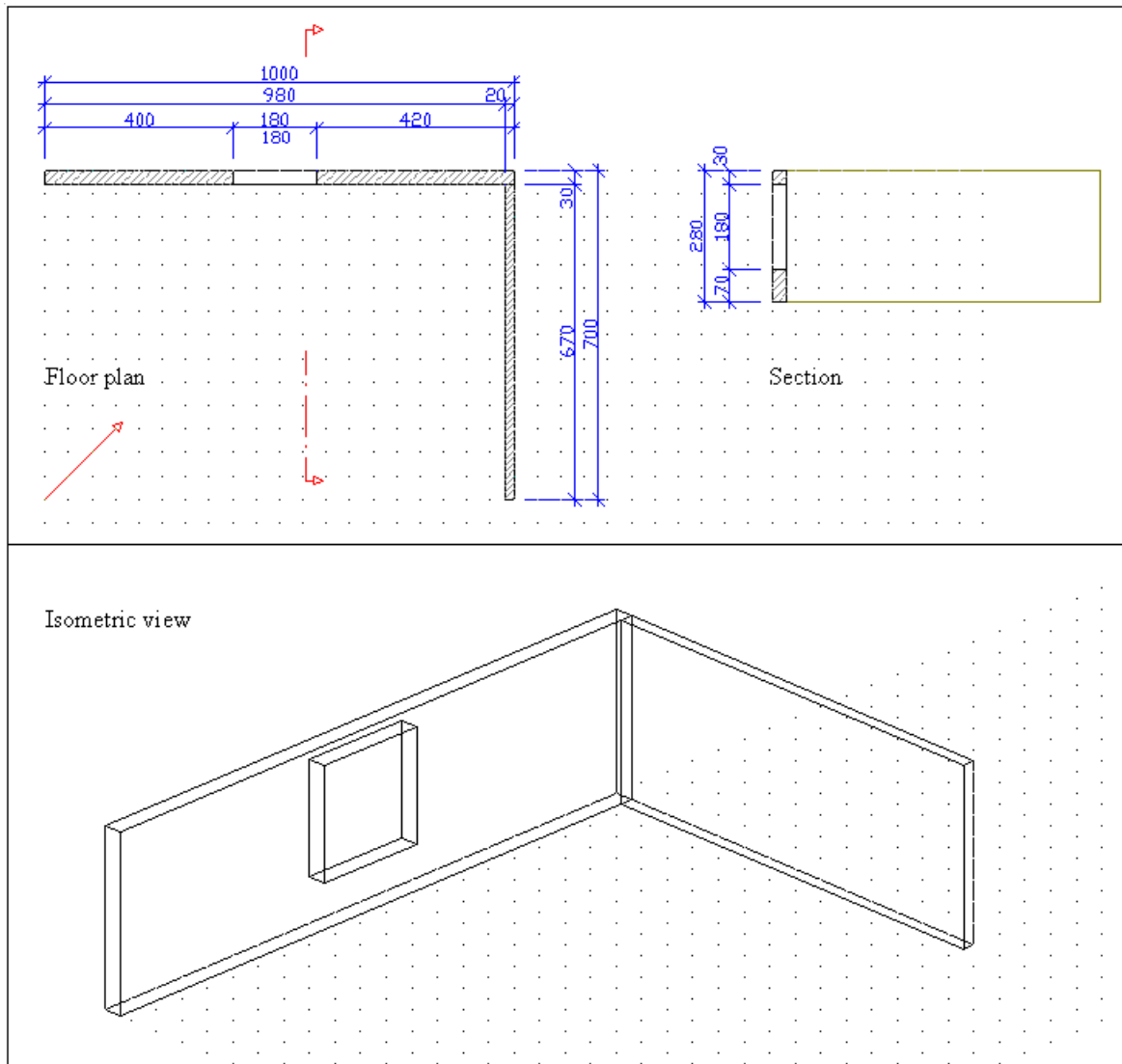
5.3.1.3. Source Test File

The file *TC001CadWallOpeningElementSource.ifc* in the test kit contains an instantiated source test case to be read into the application seeking Conformance Certification. All classes and property sets defined in this file must be supported for this Exchange View:

5.3.2. Test Case Scope – Target Benchmark File

The following main classes are tested for write out compliance by this target benchmark file: all classes that are included in the target test file, plus:

- IfcProject
- IfcSite
- IfcBuilding
- IfcBuildingStorey
- IfcWall
- IfcOpeningElement
- IfcRelConnectsPathElements
- IfcRelVoidsElements
- IfcRelContains
- IfcLocalPlacement
- IfcAttDrivenExtrudedSolid

- IfcAttDrivenExtrudedSegment
- IfcRectangleProfileDef
- IfcColumn
- IfcBeam

5.3.2.1. Test Case Summary – Target Benchmark File

The target benchmark file comprises in addition to the source test file a column and a beam. Both shall have a single material and the beam shall be supported at one end by the column and at the other end by one of the walls.

The new building elements (column and beam) are contained in a building storey, which is contained in a building , which in turn is contained in a site. All products shall be references by a project.

containment: IfcColumn, IfcBeam → IfcBuildingStorey → IfcBuilding → IfcSite
reference: IfcColumn, IfcBeam, IfcBuildingStorey, IfcBuilding, IfcSite → IfcProject

The column and the beam shall be located relative to the building storey, the building storey shall be located relative to the building, the building shall be located relative to the site, which is located relative to the world coordinate system as established by the project.

local placement IfcColumn, IfcBeam → IfcBuildingStorey → IfcBuilding → IfcSite → IfcProject

The geometric shape representation of the column and beam shall be in the context of this test case:

IfcColumn   standard geometric representation
IfcBeam   standard geometric representation

5.3.2.2. Instructions for Generating the Target Benchmark File

The column and the beam shall be inserted at the position and with the dimensions as shown in the following figure. The complete test case shall then be written out. All dimensions are given in centimetres.
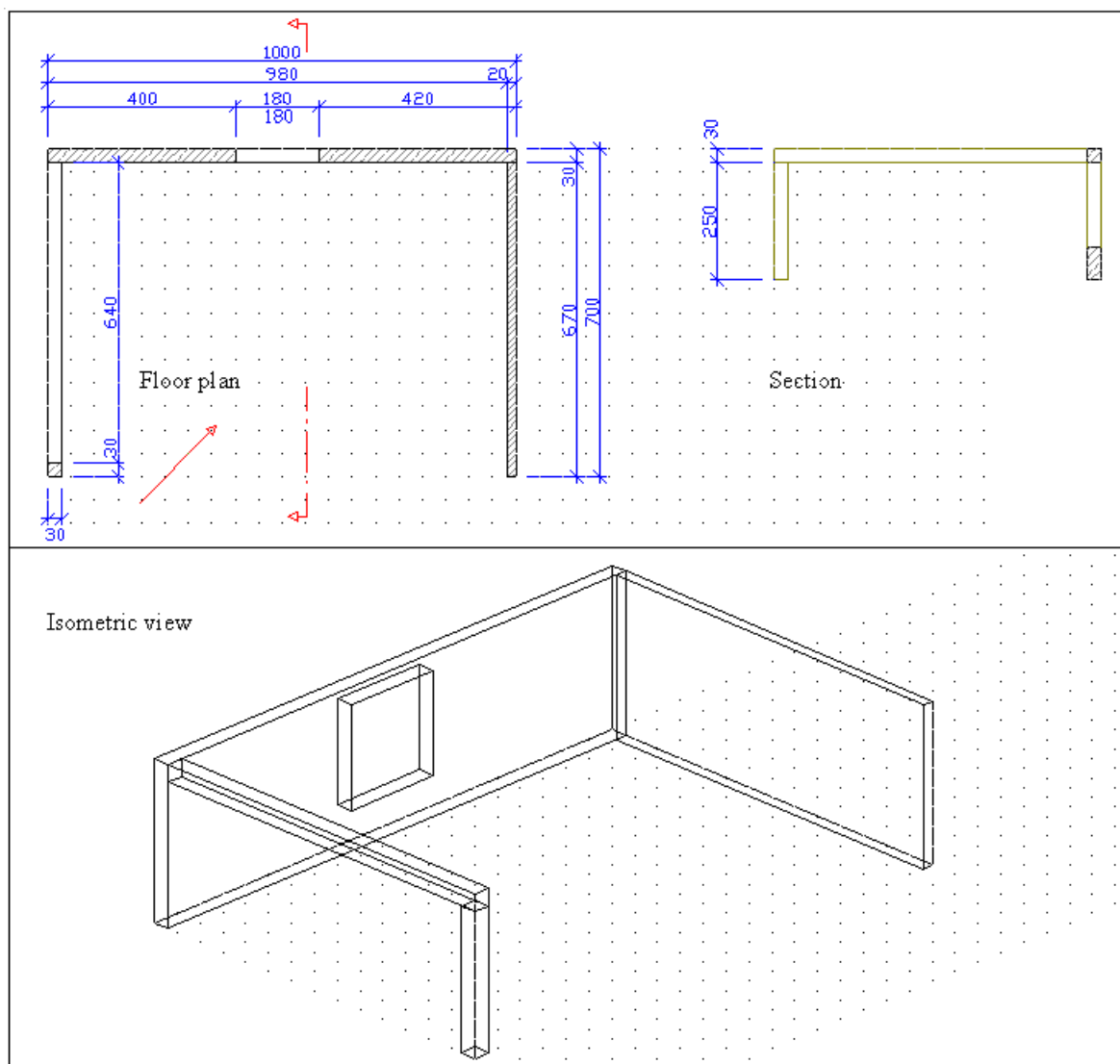
5.3.2.3. Target Benchmark File

The file *TC001CadBeamColumnTarget.ifc* in the test kit contains an instantiated target test case that should be written out by the application seeking Conformance Certification. All classes and property sets defined in this file must be supported for this Exchange View:

Appendix A: Implementation Certification Application for IFC 2.0

This appendix contains the application that must be filled out by a company representative seeking IFC certification for their application. The application must be completed in its entirety and submitted to the IAI Software Implementation Committee. Any questions regarding this application should also be directed to the IAI Software Implementation Committee.

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Implementation Certification Application for IFC 2.0

When you submit this application to the International Alliance for Interoperability (IAI), the primary contact listed below will be notified with a tracking number assigned to this application. Please save this form along with your assigned Tracking Number for future reference. The Tracking Number shall be written on all future correspondence and documentation related to this Application.

Please answer all questions in each section completely.

Company Information:

The following general information is related to the company that is submitting the application.

Company Name:			
URL:			
Address 1:			
Address 2:			
City:		State:	
Zip:		Country:	
Phone:		Facsimile:	

Primary Contact:

The Primary Contact is a company representative or employee who has overall responsibility for providing information to the IAI regarding the certification program, logo administration, and general agreement issues.

Name:			
Address 1:			
Address 2:			
City:		State:	
Zip:		Country:	
Phone:		Facsimile:	
Email:			

Technical Contact: ☐ Same as Primary Contact

The Technical Contact is a company representative or employee who has responsibility for the identification of the IFC model coverage within the product seeking certification.

Name: _____

Address 1: _____

Address 2: _____

City: _____ State: _____

Zip: _____ Country: _____

Phone: _____ Facsimile: _____

Email: _____

Marketing Contact: ☐ Same as Primary Contact

The Marketing Contact is a company representative or employee who has responsibility for marketing the product seeking certification. All validated products will be identified on the IAI web site.

Name: _____

Address 1: _____

Address 2: _____

City: _____ State: _____

Zip: _____ Country: _____

Phone: _____ Facsimile: _____

Email: _____

Product Information:

The following information concerns the product seeking certification. The description below should be confined to twenty-five words or less and will be used for describing the product on the IAI web site.

Product Name: _____

Version: _____ Ship Date: _____

Description: _____

_____

_____

_____

_____

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IFC Model Coverage:

The following information concerns the aspects of the IFC that will be addressed by the product seeking certification. Category identifies the industry segments covered within the IFC which the product will address. Exchange View identifies an existing Exchange View definition.

Category:
☐ Architecture ☐ HVAC

☐ Facilities Management ☐ Construction Management

Exchange View:

If no existing Exchange View satisfies current market needs, identify the IFC Classes and Property Sets defined in the IFC model which the product seeking certification intends to exercise. The items identified under IFC Coverage will be evaluated for consistency with other Exchange View definitions, and if necessary, a new Exchange View definition will be created to meet these requirements. Attach another sheet if necessary.

IFC Coverage: _____

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Agreement:

Upon processing of this application, the IAI will forward to the Primary Contact the Certification Test Kit for self testing. This kit includes the formal Test Cases for the subset of the model that has been identified in this Application, sample test files, file validation software and forms and procedures for documentation of the test results. The applicant accepts that all test results from the certification process will be made available to the public on the IAI web site. Furthermore, the applicant accepts that participation in an Interoperability Workshop is mandatory. These workshops are open to the public and will be administered by the IAI. Successful completion of the self test and workshop will result in the IAI granting the use of the IAI Certification Mark for the certified product. This Logo can be used in promotional and marketing materials, as well as for branding the distribution media for the validated product. The IAI reserves the right to recall the use of the logo should conditions arise which call into question the validity of the product in an interoperable environment. The applicant also agrees to include in all product documentation, either printed or electronic, information detailing the validated model coverage.

Name: _____

Signature: _____

Date: _____

IAI Chapter: _____